Description

# Encapsulation for an organic electronic component, production method therefor, and use

The invention relates to an encapsulation for an organic electronic component based on a technique that is improved with respect to imperviousness, and a production method and uses therefor.

Organic electronic components such as, for example, polymer chips, organic photovoltaic elements and/or organic light-emitting diodes are known. All of these organic electronic components include at least one organic active layer; the material of such a layer or the additional materials present in the layer structure are usually sensitive to oxidation and/or moisture, and the electronic component as a whole therefore usually has to be protected against environmental influences.

One of the most decisive factors in the commercial exploitation of any organic electronic device is the life of the component, which is determined by the stability of the organic active layer(s). The problem here is that no technique has yet been developed by which an organic light-emitting diode (LED) could be protected for example against environmental influences to such an extent that its functionality remains stable for three years or more.

At present, it is standard practice to protect organic electronic components against air and moisture by means of an encapsulation created by inverting a glass or metal cap over the component and attaching it to the substrate. The encapsulation also simultaneously protects the component against mechanical damage, and drying agents/antioxidants, etc., can additionally be fixed to the inside of the capsule.

A disadvantage of the encapsulation-based method, however, is that the material boundary between the substrate, the connecting glue and the capsule is subject to the

diffusion of atmospheric moisture and oxygen, which then severely affect the imperviousness of the structure, in particular sharply reducing the life of the component.

For this reason, an encapsulation provided with a dual adhesive bond ("rim coating") has recently been proposed, as in US 2003/0143423, in which the capsule is attached to the substrate as well as possible by means of a first, preferably inner adhesive bond, while a second, preferably outer adhesive bond prevents the ingress of moisture and oxygen insofar as possible. Here again, a disadvantage of these encapsulations is that a diffusion pathway forms along the material boundaries of the various materials (substrate, glue, encapsulation), so that ultimately the imperviousness of the encapsulation is not ideal and the component instead is still damaged by environmental influences. In particular, the barrier effect of the structure as a whole may be determined by the diffusion along the material boundaries, and may therefore be higher than the diffusion through the volume of the adhesive.[1]

The object of the present invention is, therefore, to make available an encapsulation for an organic electronic component that offers mechanical protection and optimal imperviousness against harmful environmental influences such as atmospheric moisture and/or oxygen.

The invention is therefore directed to an encapsulation for an organic electronic component, characterized in that the encapsulated component is at least partially covered with a protective film. The invention is further directed to a method for producing an encapsulation covered with a protective film, and finally to the use of an encapsulation according to one of the preceding claims [sic] to protect organic electronic components, such as organic LEDs, polymer chips and/or organic photovoltaic and/or electrochromic elements and/or display applications that are organically based.

[1]Translator's Note: Sic. Sentence appears to be garbled slightly.

The effect achieved by means of the encapsulation is that the component is protected against mechanical damage, while increased imperviousness to moisture and oxygen is obtained by the at least partial covering with a protective film.

The term "encapsulation" denotes a dimensionally stable covering over the organic electronic component, which dimensionally stable covering is inverted over the component as a finished capsule, for example of metal and/or glass, usually rests on or terminates flush with the substrate, and is then glued thereto. A version of the capsule that is made of crosslinking plastic may also be contemplated, the plastic being applied in a plastically deformable modification and being rendered dimensionally stable by subsequent curing. In cases where the capsule is made of a plastic, various properties, such as thermal conductivity (to dissipate evolved heat), absorbency, etc. can be incorporated into the capsule by the addition of suitable fillers.

In any event, the encapsulation is mechanically stable within given limits and is made of a material that is impermeable to environmental influences such as moisture and/or oxygen.

The encapsulation is preferably glued to the substrate at least once, resulting in an essentially ready-encapsulated organic electronic component, which is then additionally protected and sealed according to the invention by applying a protective film for example at weak points of the encapsulation, such as the transition from the encapsulation to the substrate.

The additional sealing by covering with a protective film can be done either solely at the weak points of the encapsulation or, preferably, over the entire exterior of the component, so that the encapsulated component is additionally completely covered with a thin-barrier film protective film.

The protective film preferably comprises[2] a thin-barrier film of the kind known from sealing technology. These films are distinguished above all by extremely low permeation rates, thereby dramatically reducing the ingress of environmental influences such as moisture and/or oxygen. The protective film can be made of organic or inorganic material, and its material therefore is not firmly established. Where appropriate, a specific property profile (thermal conductivity, color, absorptive properties, etc.) can also be imparted to the protective covering through the addition of a suitable filler, as in the case of the encapsulation.

The thin-barrier films group includes both inorganic materials and organic materials. These are characterized by low permeation rates for their class, even when implemented as thin layers (layer thicknesses of less than 1 mm).

These films can include more than one layer, but need not necessarily do so.

The inorganic layers class includes, non-exclusively, the materials to be made from metal oxides, metal nitrides, metal oxynitrides, silicon compounds and any other type of ceramic compound.

The organic materials class includes in this sense, but non-exclusively, organic compounds, preferably polymer compounds, such as, inter alia, parylenes, hydrofluorocarbons, acrylates, polyester compounds and the like.

If the protective film includes plural layers or plies, organic and inorganic layers can be arranged in any desired order. The organic and/or inorganic plies can be deposited on or laminated onto one another by known techniques or, in other methods, disposed as stand-alone[3] films on the areas to be covered. The material used for the protective film is

[2] Translator's Note: The German word *zu* is inserted here. It serves no purpose in the sentence as it stands, but suggests that the wording may previously have been *gehört zu*, (lit. "belongs to"), i.e., "The protective film is preferably one of the thin-barrier films of the kind…"

[3] Translator's Note: We assume the German *eingeständiger,* "acknowledged" or "admitted," to be an error for *eigenständiger,* "stand-alone."

preferably one that offers better insulating action against moisture and/or oxygen than the glues (even if filled with absorbent) conventionally used with the encapsulation.

The thickness of a protective film can vary from approximately 1 nm to 500 μm. In the case of inorganic films, the thickness of the protective film is preferably within a range of 1 nm to 10 μm, particularly 5 nm to 1 μm, and in the case of organic films in the range of 500 nm to 100 μm, particularly 1 μm to 50 μm.

The protective film can be applied or deposited by various techniques, among which the following methods may be cited: chemical vapor deposition, physical vapor deposition, wet chemical deposition, such as spin coating, dip coating, drop coating, printing techniques such as stencil printing, squeegee printing, screen printing, ink jet processes, spraying, plasma coating methods, plasma polymerization methods, laminating processes, hot sealing, transfer techniques (such as thermotransfer), welding methods and injection molding.

According to one embodiment of the method, the component is in a high-vacuum chamber during deposition.

According to another embodiment, the component is under reduced pressure but not in a high vacuum during deposition.

According to a preferred embodiment, the material of the thin-barrier film protective film is selected so that it can be applied by chemical vapor deposition (CVD). Due to the low degree of molecular alignment in CVD, this method makes it possible to produce a three-dimensional protective film covering of almost any desired shape, i.e. including one that is completely adapted to the encapsulated component to be covered.

A further preferred configuration of the method is designed to minimize thermal stress on the component. To this end, a material for at least one inorganic layer of the protective film is selected so that CVD coating, for example plasma-assisted, can be performed at

such low temperatures, for example less than 300°C, particularly less than 100°C, that the functionality of the component is not impaired and the effects of thermal expansion are minimized. One suitable material for this purpose is silicon nitride.

In a further advantageous configuration of the method, the organic material for layer formation in a thin-barrier film protective film is selected so that CVD coating or plasma polymerization can be performed. This is particularly advantageous because the film is completed quickly and provides conformal coating of the object. A suitable material for this purpose is parylene. The parylene group includes, inter alia, the modifications parylene N, C, D and F. All of these differ in terms of the substituents on a six-member carbon ring that is bound on both sides to a $CH_2$ group. No substituents are present in the N; C has one chlorine, D two chlorines and F one fluorine. Coating with parylene C seems to be particularly preferable since it is known to result in the best moisture barrier.

In a further preferred configuration of the invention, the thin-barrier film protective film with which the encapsulated component is covered includes at least one layer made of organic and/or one made of inorganic material. These organic and inorganic layers are for example applied in alternation.

According to one embodiment, the contacting of the component by means of, inter alia, a connecting cable bringing the organic electronic component into contact with external drive or playback electronics or another type of connection (grounding) takes place prior to the application of the thin-barrier film protective film.

The invention is described further below with reference to an exemplary embodiment:

The figure shows a cross section through an encapsulated organic electronic component covered according to the present invention with protective film.

In the figure there may be recognized the substrate 1, on which the component is disposed. Visible thereon are the component 3, comprising various active layers, and the

encapsulation 5, which is attached to the substrate 1 by means of glue 4. Disposed over the encapsulation 5 is the protective film 2, which covers parts of the substrate 1 as well.

The invention discloses for the first time a high-density encapsulation that far outperforms the known encapsulation technologies[4], since a weak point of the encapsulation, such as for example the transition from the capsule to the substrate or the electronic component as a whole, is covered with a protective film.

[4] Translator's Note: Due to a grammatical error in the German, the phrase actually reads "a high-density encapsulation that the heretofore known encapsulating technologies far outperform." (The sentence appears the same way in the abstract. The error is in the number of the verb "outperform" [*übertreffen*].)